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NASA CR-

147466

TECHNICAL MEMORANDUM

AN INTERACTIVE METHOD FOR  
DIGITIZING ZONE MAPS

(NASA-CR-147466) AN INTERACTIVE METHOD FOR  
DIGITIZING ZONE MAPS (Lockheed Electronics  
Co.) 43 p HC \$4.00 CSCL 08B

N76-18627

Unclass

G3/43 18074

Job Order 92-105

Prepared By

Life Sciences Applications Department  
Lockheed Electronics Company, Inc.  
Aerospace Systems Division  
Houston, Texas

Contract NAS 9-12200

For

HEALTH APPLICATIONS OFFICE  
LIFE SCIENCES DIRECTORATE



*National Aeronautics and Space Administration*  
**LYNDON B. JOHNSON SPACE CENTER**

**Houston, Texas**

SEPTEMBER 1975



LEC-6498

Contract NAS 9-12200  
Job Order 92-105  
JSC-09809

TECHNICAL MEMORANDUM

AN INTERACTIVE METHOD FOR  
DIGITIZING ZONE MAPS

By

L. E. Giddings

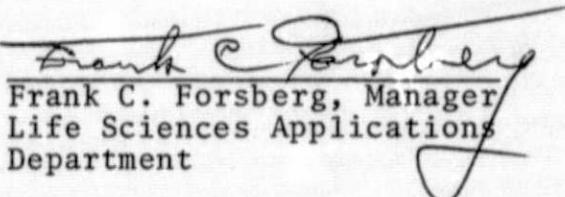
and

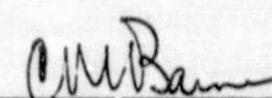
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For

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LYNDON B. JOHNSON SPACE CENTER  
HOUSTON, TEXAS

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## SUMMARY

A method is presented for digitizing maps that consist of zones, such as contour or climatic zone maps. A color-coded map is prepared by any convenient process; the map is read into memory of an Image 100 computer by means of its table scanner, using colored filters; zones are separated and stored in themes, using standard classification procedures; thematic data are written on magnetic tape; and these data, appropriately coded, are combined to make a digitized image on tape. Step-by-step procedures are given for digitization of Crop Moisture Index maps with this procedure. In addition, a complete example of the digitization of a climatic zone map is attached as an appendix.

## 1.0 INTRODUCTION

The Life Sciences Applications Department has long had need for digitizing maps. Historical records of screwworm incidence; current case reports; data on release of sterile flies; climatic zones; all these, and many other data that can be represented as zones on maps, are needed to interpret satellite data in the screwworm eradication project.

When specifications were being prepared for the operational Screwworm Eradication Data System, SEDS, to be implemented by the Ground Data Systems Division, no appropriate methods of digitizing maps were available at JSC. As a result, many needed forms of data were not included in SEDS; the system, as delivered in early 1975 had provision only for incorporation of the Crop Moisture Index, CMI, to be prepared weekly by some unspecified method. Other data that were originally specified were omitted from SEDS, with the objection, at least in part, that a practical technology for digitizing maps did not yet exist at JSC.

The Image 100, activated in the Earth Observations Division of NASA in early 1975, provided a fairly direct means of digitizing maps for the SEDS system. The procedure presented here was developed for nearly real-time digitization of the Crop Moisture Index using this device followed by processing with the Aerojet DAS. It allows digitization of this and other zone maps within a few hours of reception of a hand-colored image. Its disadvantages lie mostly in the specialized training needed to perform the classifications and to clean the image of unassigned or badly assigned pixels. In short, it is highly dependent on training of the operators of the Image 100 system.

To avoid these difficulties an auxiliary way of preparing these images is now in development. This procedure will take somewhat longer, but it will always be available in case trained personnel are not available. It will also allow the use of digitizers other than the one with the Image 100, in case the latter is not in operation.

## 2.0 THE GENERAL PROBLEM OF DIGITIZING MAPS

### 2.1 EQUIPMENT AT JSC

Several items of equipment for digitizing images can be found at the JSC. The Photo Technology Laboratory has several scanning densitometers, most of which could probably be used quite economically for digitizing maps. However, none have been used for this particular purpose because of format problems and the ready availability of the Image 100 system.

Probably the most useful candidate equipment for digitizing maps, aside from the Image 100 system, are the Calma VIP 303 digitizing and plotting system, and the Bendix 100 interactive drafting system, combined with the Gerber plotting device in Building 17, both at JSC. This department experimented a bit with the former, but found no straightforward way of converting the raw product to a useful product. Essentially, this system coded the lines and samples of borders of zones, but it seemed difficult to insert values within zones. At this writing, no programs exist for either device that would allow coding of all pixels within zones.

### 2.2 ADVANTAGES OF THE IMAGE 100

When the Image 100 was installed in Building 17, this department paid particular attention to its digitizing capability. It became apparent that it presented the possibility of a quick, though inelegant, method of digitizing images on a production basis.

The Image 100 is uniquely versatile for the manipulation of images. One can place one image in memory by reading a tape. He may then register another image to it using its table scanner, and read it into another portion of the memory. He may then use a series of hard-wired programs to perform an interactive classification which results in the separation of zones in the map. Starting with a colored image, an output tape with separated zones can be prepared in one sitting.

### 2.3 AN OVERVIEW OF THIS METHOD

This method depends on the preparation of a map in which zones are distinguished by color or by grey scales. A transparent or opaque image is prepared by any available way, such as painting, cutting and pasting, or by photography. This image, essentially a color-coded map, is registered to the grid system of the Image 100 using its table scanner. It is then read into the memory of the computer, directly in the case of a grey-scale image, or through three or four color filters in the case of a color image. The zones are separated by standard classification procedures and stored in themes. The themes are written on a tape that is processed on the Aerojet DAS system to produce a LARsys-III tape, which may be converted to a Universal format. The output product tape contains a value for all pixels in the image.

## 3.0 PREPARING MAPS

### 3.1 LIMITATIONS ON MAPS

This method is applicable to all maps which can be reduced to discrete zones. In the output product, each zone will be identified by an integer from 1 to 255, used as a numerical value, or, more simply, for identification of the zone.

Probably most maps can be digitized in this way. The Crop Moisture Index maps, CMI, contain numbers for each zone; but since the CMI varies from about -8 through +8, the values actually recorded on the digitized map are encoded values. Vegetation, climate, emissivity, or other maps consisting of zones are also well suited to this method.

Ordinary altitude maps and other isolinear maps are also well suited if attention is focussed on the contents of zones rather than the lines separating them. For example, two consecutive contour lines of 150 and 160 meters delineate a zone which might be considered the 155 meter zone.

For certain purposes, even geographical or political maps can be digitized in this way. Lines and letters can be considered a single zone, and political or other boundaries can be considered others. However, except for merely reproducing them, there is little point to their digitization. In any case, hachures and other continuously variable features can not be digitized in this way.

Some limitations need to be kept in mind. As described here, a maximum of fourteen zones can be handled very conveniently. However, 35 zones or more can be separated fairly easily, and even greater numbers can be isolated with obvious modifications to this system.

Resolution can also be a problem. Each map may contain only 512 X 512 pixels, a number which is inadequate for many purposes. Several maps can be digitized and later merged into a single large one, but the problem of registration may be difficult to handle.

### 3.2 PREPARATION OF THE MAP

To be digitized, the map must be between 2 3/4 inches (70mm) and 6 1/2 inches (16mm) on its longest edge; the former limitation is due to the optics of the Image 100 scanner, and the latter is dependent on available light for opaque images. For most uses, zones must be colored to their edges, not outlined by black lines. All annotations should be absent in the normal case.

Color-coded images may be opaque, such as hand-painted images, or they may be transparent. The Image 100 system was designed for transparencies, but in practice the use of transparencies requires a so-called shading correction to compensate for unequal illumination.

A photographic reproduction is most convenient for preparation of color transparencies for this use. The map can be colored by tempera colors (opaque water colors) or any other opaque colors, and then photographed, preferably to yield a 4" x 5" color positive transparency.

To eliminate the time-consuming photographic process, the map can be prepared at the right size to be used directly. Several processes are possible. One that is adequate for some uses involves the reduction of a large image by a reducing zerox copying machine and the painting of zones with tempera colors. A better alternative would involve the construction of an image with colored construction paper; this would offer quite uniform colors.

### 3.3 PREPARATION OF CROP MOISTURE INDEX MAPS

The following steps document the preparation of opaque color-coded Crop Moisture Index Maps in great detail.

Materials needed: map to be digitized, tempera colors, appropriate brushes, forms: "Contents of LARsys II Tape from the Image 100" (see Figure 1).

Equipment needed: access to a reducing zerox copying machine.

1. Receive 14" x 18" hand-drawn CMI map on outline map from meteorologist, with value of each zone identified.

2. Using reducing zerox copying machine, reduce map to about 6 inches on the longest edge. This normally requires 5x reduction followed by a 4x reduction.

3. Examine map for entire range of values of zones. Place values in order from largest to smallest in the "Insert" column of the form. As an example, the following values are in the proper order: +2.5, +0.25, -0.25, -0.75, -1.5.

4. Color each land zone a different color with tempera colors. As each zone is colored, its color should be noted in the "color" column of the form and a sample painted in the appropriate training field included on the map (see Figures A-1 and A-2 in the appendix).

5. Color all water areas white. Paint white on the next line of the form and in the water training field, and write "water" in the "contents" column.

6. Color all unassigned training fields grey.

7. Precaution: Each zone must be a different color, to ensure compatibility with automatic systems which are being developed. Eventually a single color code may be specified.

8. Precaution: It is convenient for adjacent colors to be quite different. For example, zones next to each other should not be colored light and dark blue; blue and yellow would be more appropriate.

9. Precaution: The color zones must be pure. For example, all black lines, such as grid lines, must be completely covered up, and there should be no streaks within zones.

CONTENTS OF LARSSY II TAPE FROM  
THE IMAGE 100

CMI _____	Title: _____	Drawing _____	Date _____
Special _____	Tape No: _____	Themes _____	_____
Final Format: _____ x _____	Number of lines to be skipped: _____	Conversion _____	_____

OVERALL CONTENTS

Channel 1  
Channel 2  
Channel 3  
Channel 4  
Channel 5

THEMES\* (maximum of 35; use more sheets if necessary)

<u>Channel/Theme</u>	<u>Color</u>	<u>Insert**</u>	<u>Contents</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

DIAGNOSTICS

Ignore diagnostics? \_\_\_\_\_

For pixels assigned to more than one theme: Insert \_\_\_\_\_

For pixels not assigned to themes: Insert \_\_\_\_\_

\* Themes are prepared in channel 5 but may be transferred to any other channel.

\*\* Write "invert" if the inverse is to be used (that is, a value inserted for all pixels not in the theme).

sheet \_\_\_\_\_ of \_\_\_\_\_

Figure 1.- This is a convenient form for use in digitizing  
zone maps.

10. Examine print for errors using the original handdrawn map as a guide. Correct any errors.
11. Examine finished map for quality. Map should be flat, with pure colors covering all portions. No lines or annotations should be visible. There should be no ridges or peaks visible on the paper because of thick paint.
12. Note any discrepancies or comments on the bottom or on the back of the form.
13. Pass colored map, original map, and form to the person who is to perform the digitization.

## 4.0 PROCESSING ON THE IMAGE 100

### 4.1 AN OVERVIEW OF THE PROCEDURE

This procedure takes a color-coded image and converts it to a digital tape. In brief, using the table scanner of the Image 100, the color-coded image is registered to the television screen, then read into memory through several color filters. The colored zones are separated by standard classification procedures, and stored in separate themes. In the normal case, since there will be more than seven themes, more than one channel will be needed for storing themes. Finally, all channels will be read out in a LARSYS format for further processing.

### 4.2 THE PROCEDURE IN GREAT DETAIL

The following are the detailed steps required for digitizing Crop Moisture Index Maps:

Materials needed: color coded image; the form with the color key to the coding; the handdrawn CMI map for reference.

Equipment needed: the basic Image 100 computer with standard programs; table scanner with primary color filters; for illumination, at least two double-bulb fluorescent desk lamps; the LARS 5 program, or other program that will produce a 5-channel LARSYS tape.

1. Place standard image in memory - Read in standard images as a basis for registration. If images are read from SMD tapes from the Screwworm Eradication Data System, SEDS, use the following parameters:

(1,1) (2560,2455) (0,20) (511,511)

(At this writing, standard images are contained in the REGIS 1 file on a Video I/O tape.) (For digitization of other than CMI tapes, this step may not be necessary.)

2. Place color-coded map in scanner - Place the color-coded map in the glass holder of the Image 100 table scanner. If the map is transparent, use the normal substage light of the scanner. If it is opaque, turn off the substage light and play at least two fluorescent desk lamps on the map. Two photoflood lamps controlled by an adjustable auto-transformer (a Variac) give great flexibility in illumination. Use the green color filter on the camera to obtain the proper intensity of light. Adjust lights to give the most uniform illumination if an opaque image is to be digitized.

3. Register color-coded image - Register the color-coded map to the image in memory by adjusting translation, rotation, height and focus of the table scanner camera. Since there are often discrepancies in registration in the SEDS system, judgement must often be used. However, the color-coded image should be slightly larger than the image in memory if it cannot be made to register exactly; in particular, all land areas on the image in memory must be overlaid by some land portion of the color-coded map.

4. Read color-coded image into memory - Turn the filter to blue and adjust the aperture of the lens to give a good image on the screen. If a variable autotransformer is used with incandescent lamps, such as photofloods, it will be convenient to adjust voltage to lamps instead of adjusting aperture. Turn the channel number on the console to 1, press the erase button, and then press the load button; or, use the video scanner averaging feature, with six scans. Change the filter to green, adjust the illumination, erase, and load the yellow filtered image into channel 2. Repeat

the entire sequence of steps for the red filter and channel 3, and, if desired, for the near infrared filter in channel 4. Turn off the table scanner and display channels 1 through 3 with blue, green, and red, in order. The screened image should be similar to the original color-coded image. If it is not, the process should be repeated, adjusting the parameters that are deficient. If it is not possible to read images into memory at appropriate intensity levels, it may be possible to adjust intensities by the thumb wheels in the pre-processing section. Preferred filters are Wratten blue: 98, light yellow: 50Y, red: 25, and near infrared 89B.

5. Urgent Information - Illuminating the image is probably the most critical step in this entire procedure. If an opaque image is very evenly illuminated, a typical image may require two or so hours to process on the Image 100 system. If illumination varies from edge to center or in any other way, processing time may exceed ten hours. Every effort must be taken to make illumination completely uniform across the colored image. Experience has shown that the shading correction program on the Image 100 will greatly help with transparent images, but no general rule can be given for opaque images.

6. Preserve Image - To guard against accidental loss of this image, it is preferable to copy all channels onto a video 1/0 tape, preferably coded as CMI. Have a tape mounted and zeroed. Then, press the video 1/0 and execute buttons, and save all channels by writing out a tape. Leave tape mounted for saving themes as specified below in steps 11 and 12.

7. Set Parameters - If only three channels are used, press

the "parameters" and "execute" buttons on the console. Use default options for all but the number of channels, which should be set at 3. If four are used, the number of channels is allowed to remain at 4.

8. Assign Channels and Themes - Tentatively assign blocks of themes to channels, and enter these assignments on the form. Normally, proceeding from highest to lowest values of CMI, assign first seven zones to themes 2-8 of channel 4, the next seven to 2-8 of channel 3, etc., ending with the last batch of themes in channel 5. All themes are prepared in channel 5, but some may need to be stored in other channels for processing in subsequent steps.

9. Set first theme - Use standard procedures to "alarm" the first zone, normally through the 1-dimensional training and 1-dimensional display features, using the training field on the image. Place the alarm in theme 2, perhaps using both theme and cursor options. Using logical functions, fill in all holes and remove all extraneous pixels. (Theme 1 should not be used because of logical errors which occur in the Image 100). Complete the form for this theme, noting any special problems on the back of the form.

10. Set next six themes - By the same process, alarm the second theme and transfer it to theme 3. Clean out extraneous alarmed pixels, fill holes, and fill in the entire border area with the previous theme. Using the logical functions, subtract the previous theme. Repeat the same process with the next five zones. In each case, note that the form contains the appropriate information, and note any discrepancies. (Note that as a result of transfer of channels, theme 1 will always contain the inverse of themes 2 through 8 in addition to its content. Theme 1 generates this normally extraneous data because zeros are not permitted

as pixel values during transfer of data.)

11. Read out all themes on a "video I/O" tape for channel 5 only, preferably coded as channel 4 if these themes are to be assigned to channel 4 later.

12. Set remaining themes, seven at a time - The next theme should be prepared, with its boundary adjusted to previous themes in composite on the inverse of theme 1. The remaining themes should be prepared as before, including water in the case of CMI. Sets of themes should be read onto a video I/O tape coded as CHANX where X designates the final channel assignment.

13. Read themes into position - After all themes have been prepared and read out onto a video I/O tape (in each case as a single channel "save" of channel 5), it is necessary to emplace them in the proper channel of the Image 100 memory. Press the video I/O and execute buttons to restore channels; note that CHAN4 is to be restored to channel 4 even though it was saved from channel 5. Repeat until all themes are in position in the appropriate channels. It is best to label and preserve this video I/O tape until it can be shown that all subsequent processing has been successful.

14. Diagnosing problems - Examine data for dropouts and other defects. In many cases, default options may be specified to compensate for these defects.

15. Write data on tape - Using LARS 5, prepare a five-channel LARSSYS-II tape of all data in the memory of the Image 100.

#### 4.3 PREPARATION OF THE FORM

The form, "Contents of LARSSYS II Tape from the Image 100" will have been received with the color coded map, with annotations in the Color, Insert and Contents columns. During

the digitization, the channel/theme column should have been filled out, designating the channel where the theme is to be stored.

For "number of lines to be skipped" insert 20 for the CMI if the standard image was read from SMD or SMN tapes as specified in step 1. This compensates for the invisibility of the top portion of the Image 100 screen, a defect of the present model.

For title, insert the date of the CMI or any other title.

For the CMI, insert 625 x 550 for "final format".

For the Overall Contents portion of the form note the contents of each channel. For example, channel 1 will probably contain "CMI map through blue filter," and channels 4 and 5 will normally contain themes.

On review of the total image, some pixels may be found to lack assignments; that is to say, they may constitute apparent holes in the data. In such a case, a diagnostic feature, noted on the form, can be used to assign a value to such elements. Another diagnostic option may be used to correct multiple assignments of pixels.

#### 4.4 MODIFICATIONS

Operation of the Image 100 for this project requires the services of a highly trained person. Manipulation of the logical functions as well as general classification operations are strongly dependent on the skill and experience of the operator.

Since skilled operators will use a variety of techniques for classifying the color zones, no details have been given in steps 9 through 12. Each operator should use the techniques that are most efficient for his own work.

Some additions and modifications to existing Image 100 programs were needed for this project. Most important, the LAR 5 output program, which produces a LARSYS II tape containing all five channels was needed. This provided a link with the Aerojet DAS system described in the next section.

It should be noted here that the DAS operations might just as easily have been programmed for the Image 100. This might be a future modification of value to other users.

One special program needs to be developed to speed up operations on the Image 100. A large fraction of an operator's time is taken in cleaning up themes, that is, filling holes, and removing isolated pixels. This can be performed by a separate program which places values in pixels on the basis of decisions involving adjacent pixels. Such a program would eliminate a quarter to a half of the processing time presently required.

## 5.0 PROCESSING ON THE AEROJET DAS

- - - - - NOTE - - - - -

The software required to perform this task on the Aerojet DAS was developed by the LEC Life Sciences Applications Department and is not a part of the approved system software. It is available for use on application to the Life Sciences Applications Department.

### 5.1 FORM OF DATA AS RECEIVED FROM IMAGE 100

The output of the Image 100 system is a five (5) channel computer compatible tape, CCT, in a LARS III format. Theme data can be located on any or all of the five channels. Each data channel contains 512 scan lines of 512 pixels each.

A pixel is defined as an eight (8) bit data word. The theme format is such that each bit of an 8-bit data word contains the information for a separate theme, thereby allowing a maximum of 8 themes per channel. Refer to Figure 2 for an example of a typical theme output channel.

## 5.2 AN OVERVIEW OF THE PROCEDURE

The Theme Combine Program (TCP) allows the user to assign numerical codes to selected themes and combine these themes into a single channel composite image on a computer compatible tape. Refer to Figure 3 for the form of combination.

The TCP will allow codes to be input in either of two modes, the Crop Moisture Index (CMI) mode and the SPECIAL mode.

The ability to scale the size of the image is provided in the form of a separate vertical and horizontal zoom capability. This allows tapes to be produced with fewer or more lines or pixels than the product of the Image 100 system. When operating in the CMI mode, the numeric code in counts stored on the tape is computed from the equation:

$$\text{Counts} = (8.00 \pm \text{CMI}) \times 16$$

This mode allows CMI values between -8.00 and +7.99 to be selected.

The SPECIAL mode allows the direct input of the numeric code in counts over the range from 0 to 255.

Diagnostics are also available for assigning special codes to data points which have double assignments and also to data points which were not assigned a code value during theme combining.

If the diagnostics are ignored and a data point has a double assignment, the last theme entered will overlay any other. Refer to Figure 3 for an example of double assignment with diagnostics ignored.

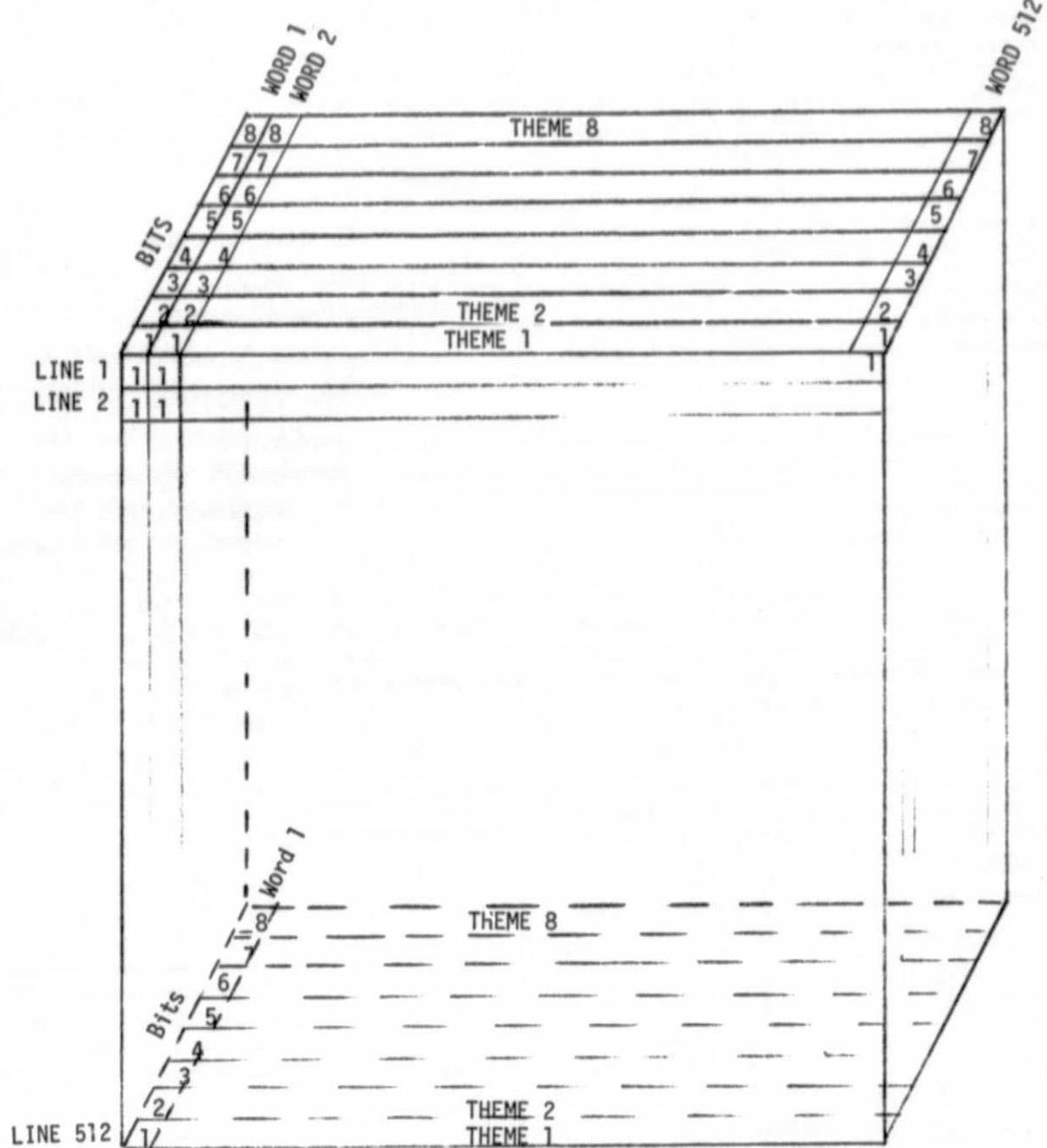
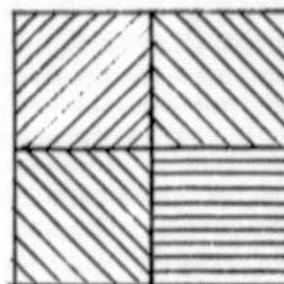


Figure 2.- Typical channel containing theme data

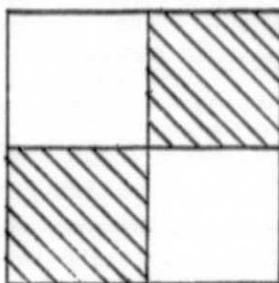
OUTPUT



Combined Output  
stored on CCT

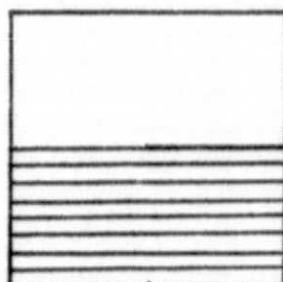
---

INPUT



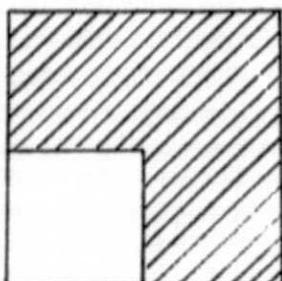
Third Theme assigned

Channel 5/Theme 8



Second Theme assigned

Channel 3/Theme 1



First Theme assigned

Channel 3/Theme 4

Figure 3.- Example of combining three themes with diagnostics ignored

### 5.3 OPERATION OF THE PROGRAM

The following are the detailed steps required for operating the Theme Combine Program (TCP):

Equipment needed: Aerojet DAS or equivalent system. ABSDMP of TCP (can be obtained from Life Sciences Applications Department personnel).

1. Load program TCP from ABSDMP CCT utilizing the system loader routine.
2. Mount Image 100 output tape on Magnetic Tape Unit (MTU) 1 and a scratch tape on MTU 2.
3. Enter program at 1100. The teletype (TTY) will respond with a request for EDIT        to be processed. Enter edit number, normally 1. The system will advance to selected edit, read the header recorder and TTY will print out:

TAPE NUMBER (0000)

NUMBER OF SAMPLES/CHANNEL (512)

CMI/SPEC

The CMI/SPEC printout is a mode request. Enter "C" for CMI or "S" for SPECIAL.

4. After the mode has been selected, the TTY will respond with "START SCAN (21).". This is a request for the first line of data to be processed on the input tape, normally 21 for a CMI run. Enter start scan number and CR.
5. The TTY will respond with "STOP SCAN (461)". This is a request for the last line of data to be processed on the input tape 1 normally 461 for a CMI run. Enter stop scan number and CK.

The SEDS system requires an input tape with exactly 625 samples/line and exactly 550 lines per image. The I-100 output tape is 512 samples/line with 512 lines. As will be shown later, this program is operated with a vertical and

horizontal zoom of 1.25 in order to meet SEDS input requirements. The stop scan of 461 is utilized to provide a 550 line output tape

STOP SCAN	461
<u>START SCAN</u>	<u>21</u>
Scan lines processed	440 x 1.25 (zoom)=550

6. The TTY will respond with: ZOOM

VERTICAL (125)  
HORIZONTAL (125)

This is a request for enlargement or ZOOM factor. The ZOOM factor entry must be multiplied by 100 before entering. The normal ZOOM factor is 1.25 and therefore 125 is entered. ZOOM factors from 0.01 to 99.99 may be entered. Enter ZOOM factor and CR.

7. The TTY will respond with =

SELECT CHANNEL/THEME

Typical examples for CMI mode would be to enter theme 5 of channel 3 with a CMI of positive 1.75. This is a request to insert the CMI value for all pixels in the theme. Enter the channel number (3), slash (/), theme number (5), and a comma (,) (3/5,). The TTY will respond with

"CMI \_\_\_\_\_ "

This is a request for the CMI input multiplied by 100 with sign if negative. In the above example enter 175 and a comma if more themes are to be entered or a CR if this is the last entry. The total TTY printout would appear as

3/5, CMI 175, (or CR)

Should an inverse assignment be desired, that is, to insert the CMI value for all pixels not in the theme, a minus sign should precede the channel number. For example, if it is desired to enter an inverse assignment on theme 7, channel 4 with a CMI value of -4.5.

The total TTY printout would appear as:

-4/7, CMI -450

A typical example for the SPECIAL mode would be to enter theme 7 of channel 2 with a code of 80. Enter the channel number (2), slash (/), theme number (7), and a comma (,). The TTY will respond with

"CODE \_\_\_\_\_"

This is a request for the special code (0 to 255) which is input directly. In this example enter 80 and a comma if more themes are to be entered or a CR if this is the last entry. The total TTY printout would appear as

2/7, CODE 80,

Should an inverse assignment be desired, a minus sign should precede the channel number.

8. After the last theme and CMI or code value has been entered and terminated by a CR, the TTY will respond with:

DIAGNOSTICS \_\_\_\_\_

This is a request for operator input as to whether or not diagnostic values for pixels assigned to more than one theme and pixels not assigned to themes are to be input. Enter "N" for no and "Y" for yes. If "N" is entered, the program will proceed to process input tape. Depending on whether the CMI or SPECIAL mode was selected, if "Y" is entered the TTY will respond with:

MULTIPLE THEMES CMI \_\_\_\_\_

EMPTY THEMES CMI \_\_\_\_\_

or MULTIPLE THEMES CODE \_\_\_\_\_

EMPTY THEMES CODE \_\_\_\_\_

This is a request for CMI value or SPECIAL code to be assigned. For example, if it is desired to enter a CMI of -4.50 for multiple themes and +5.00 for empty themes the total TTY printout would appear as

DIAGNOSTICS Y

MULTIPLE THEMES CMI -450 (CR)

EMPTY THEMES CMI 500 (CR)

The program would then proceed to process input data.

9. At this point, the digitized map is produced in LARSYS format on the scratch tape. When finished, all tapes automatically rewind.

10. When job is complete and tapes have rewound the output tape (MTU 2) should be converted to universal format using the L3UF program. Refer to system documentation for operating procedures. The final product can be screened utilizing the USEP program.

Special Notes - To remake a channel/theme line if a mistake has been made, hit rubout.

If a more serious error has been made, the program must be reinitiated.

Negative CMI values are acceptable. Special values must be positive.

## APPENDIX A

### Complete Example: Preparation of a Crop Moisture Index Tape

The Crop Moisture Index, an elaboration of the Palmer Drought Index, is one of several types of data used to calculate the potential for growth of screwworms in the Screwworm Eradication Data System. It is prepared on the basis of historical records, in combination with current rainfall and temperature data. It must be calculated and used on a weekly basis.

For the Screwworm Eradication Data System, this index is calculated for about thirty stations in Mexico, using programs adapted under the direction of Dale Phinney. The use of these programs is described in Phinney's memo, "CMI Handling Procedures", Ref. 622-750, To the Record, dated May 20, 1975.

Calculated values of the index are converted to a hand-drawn map, shown in Figure A-1, (smaller than original size). This map is reduced and colored by hand, yielding Figure A-2 (reproduced in black and white). The form, shown completed in Figure A-3, provides all information needed to convert the five channel Image 100 output tape to the single channel tape needed by the Screwworm Eradication Data System. The teletype record from the DAS is included in A-4. A portion of the final product, reproduced as a grey map, is shown in Figure A-5.

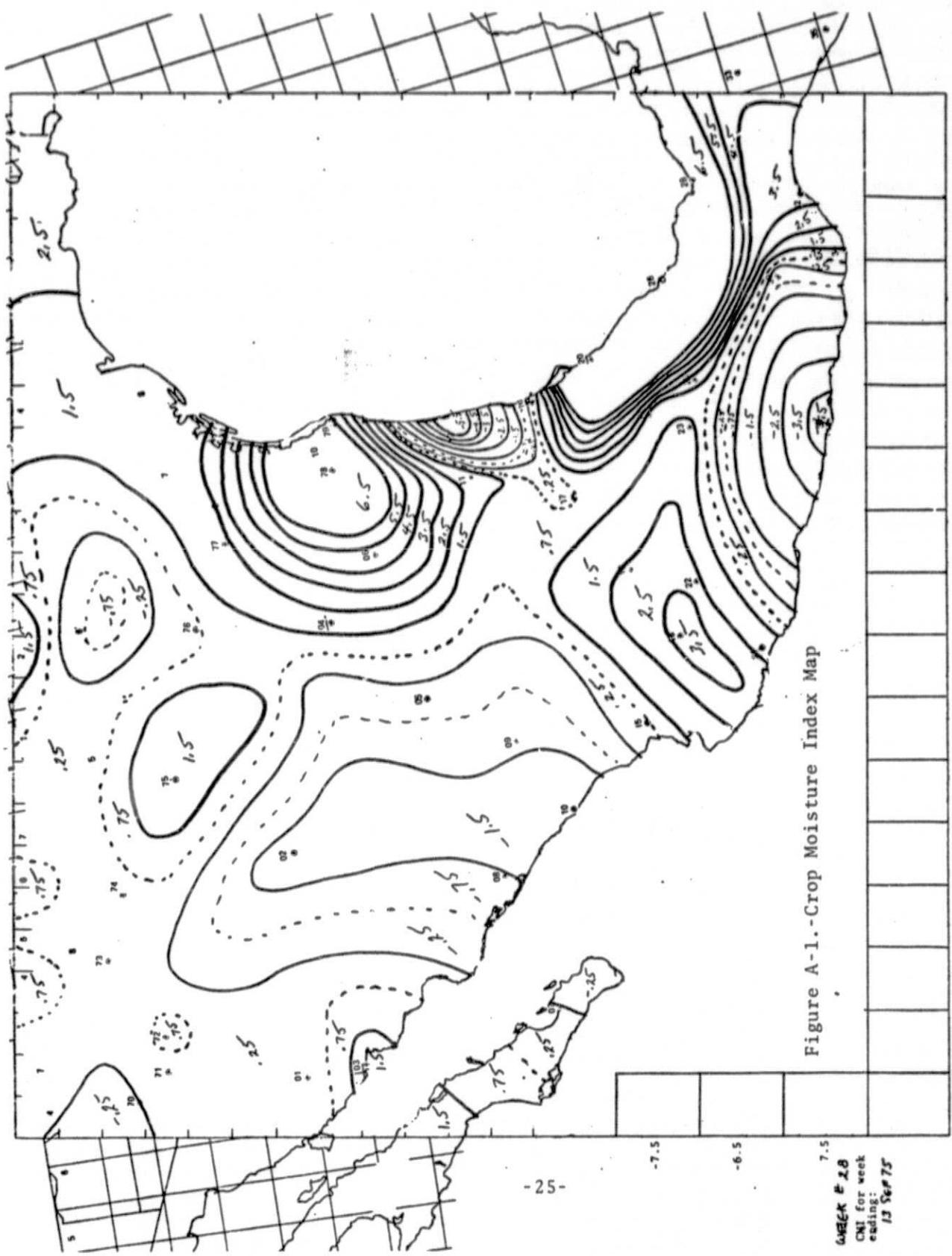


Figure A-1.-Crop Moisture Index Map

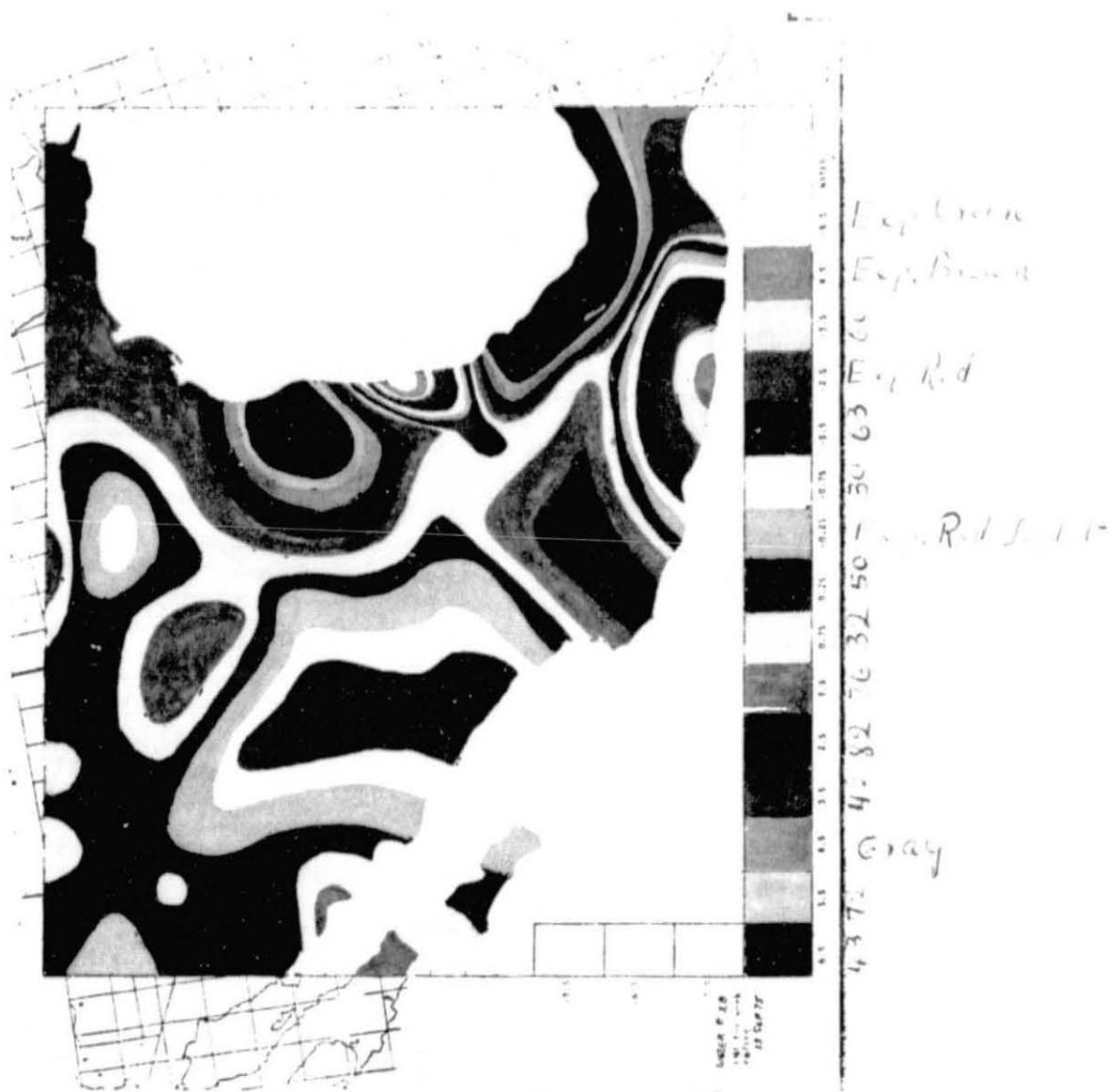


Figure A-2.-Color-Coded Crop Moisture Index Map  
(Original in colors.)

- 26 -

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## CONTENTS OF LARSHY II TAPE FROM

THE IMAGE 100

CMI X Title: CII WEEK ENDING 12 Sept 1975 Prepared by \_\_\_\_\_ Date \_\_\_\_\_  
 Special \_\_\_\_\_ Tape No: Themes \_\_\_\_\_  
 Final Format: 625 x 550 Number of lines to be skipped: 20 Conversion \_\_\_\_\_

OVERALL CONTENTS

Channel 1  
 Channel 2  
 Channel 3  
 Channel 4 THEMES  
 Channel 5 THEMES

THEMES\* (maximum of 35; use more sheets if necessary)

<u>Channel/Theme</u>	<u>Color</u>	<u>Insert**</u>	<u>Contents</u>
<u>1</u>	—	<u>7.9</u>	<u>ALL ABOVE 7.5</u>
<u>1</u>	—	<u>7.5</u>	_____
<u>1/2</u>	█	<u>6.5</u>	_____
<u>1/3</u>	█	<u>5.5</u>	_____
<u>1/4</u>	█	<u>4.5</u>	_____
<u>1/5</u>	█	<u>3.5</u>	_____
<u>1/6</u>	█	<u>2.5</u>	_____
<u>1/7</u>	█	<u>1.5</u>	_____
<u>3/2</u>	—	<u>0.75</u>	_____
<u>3/3</u>	█	<u>0.25</u>	_____
<u>3/4</u>	█	<u>-0.25</u>	_____
<u>3/5</u>	█	<u>-0.75</u>	_____
<u>3/6</u>	█	<u>-1.5</u>	_____
<u>3/7</u>	█	<u>-2.5</u>	_____

DIAGNOSTICS

Ignore diagnostics? \_\_\_\_\_

For pixels assigned to more than one theme: Insert \_\_\_\_\_

For pixels not assigned to themes: Insert \_\_\_\_\_

\* Themes are prepared in channel 5 but may be transferred to any other channel.

\*\* Write "invert" if the inverse is to be used (that is, a value inserted for all pixels not in the theme).sheet 1 of 2Figure A-3.-(on two pages) Completed Coding Form for  
Crop Moisture Index

CONTENTS OF LARSSY II TAPE FROM  
THE IMAGE 100

CMI _____	Title: _____	Prepared by _____	Date _____
Special _____	Tape No: _____	Drawing _____	9-18-78
Final		Themes _____	_____
Format: _____ x _____	Number of lines to be skipped: _____	Conversion _____	_____

OVERALL CONTENTS

Channel 1

Channel 2

Channel 3

Channel 4

Channel 5

THEMES\* (maximum of 35; use more sheets if necessary)

<u>Channel/Theme</u>	<u>Color</u>	<u>Insert**</u>	<u>Contents</u>
5/2	—	-3.5	_____
5/3	—	-4.5	_____
5/4	—	-5.5	_____
/	—	-6.5	_____
/	—	-7.5	_____
/	—	-7.9	ALL BELOW -7.5
5/5	—	3.0	WATER
/	—	—	_____
/	—	—	_____
/	—	—	_____
/	—	—	_____
/	—	—	_____
/	—	—	_____
/	—	—	_____

DIAGNOSTICS

Ignore diagnostics? N

For pixels assigned to more than one theme: Insert -2.5

For pixels not assigned to themes: Insert -1.25

\* Themes are prepared in channel 5 but may be transferred to any other channel.

\*\* Write "invert" if the inverse is to be used (that is, a value inserted for all pixels not in the theme).

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sheet 2 of 2

?  
EDIT  
APE NUMBER 00000  
SAMPLES 00512  
CMI/SPEC C  
3 START SCAN 21  
4 STOP SCAN 461  
ZOOM  
VERTICAL 125  
HORIZONTAL 125  
SELECT CHANNEL/THEME  
4/8,CMI 650,  
4/3,CMI 550,  
4/4,CMI 450,  
4/5,CMI 350,  
4/6,CMI 250,  
4/7,CMI 150,  
3/2,CMI 075,  
3/3,CMI 025,  
3/4,CMI -025,  
3/5,CMI -075,  
3/6,CMI -150,  
3/7,CMI -250,  
5/2,CMI -350,  
5/3,CMI -450,  
5/4,CMI -550,  
5/5,CMI 300  
DIAGNOSTIC Y

MULTIPLE THEMES YCMI -250  
EMPTY THEMES YCMI -250

Figure A-4.- Teletype record from DAS for conversion of Crop Moisture Index Map

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KEYMAP OF CM128 (GREATLY SIMPLIFIED)

卷之三

(#1) \* (#2) / (#3) - (#4) + (#5) , (#6) @ (#7) = (#8)  
THEME \* THEME / THEME - THEME + THEME , THEME @ THEME = THEME

卷之三

Figure A-5.-Greatly Simplified Greymap of Final Crop Moisture Index  
Tape (on three pages)

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IMAGE-100 \*OK

IMAGE-100.indd

Year	Event
1871	革命
1881	革命
1891	革命
1901	革命
1911	革命
1921	革命
1931	革命
1941	革命
1951	革命
1961	革命
1971	革命
1981	革命
1991	革命
2001	革命
2011	革命
2021	革命
2031	革命
2041	革命
2051	革命
2061	革命
2071	革命
2081	革命
2091	革命
2101	革命
2111	革命
2121	革命
2131	革命

## APPENDIX B

### Complete Example: Preparation of a Special Tape

For correlation of botanical specimens collected in the field with parameters of climate, a digitized climate map was needed. Figure B-1 shows a color-coded map of the climatic zones of the state of Veracruz, Mexico (reproduced in black and white). Figure B-2 shows the form which specified location of all climatic data, and Figure B-3 presents the teletype record from the conversion process on the DAS. The final image, presented in part in B-4 as a grey map, contains a code number identifying each climatic zone.

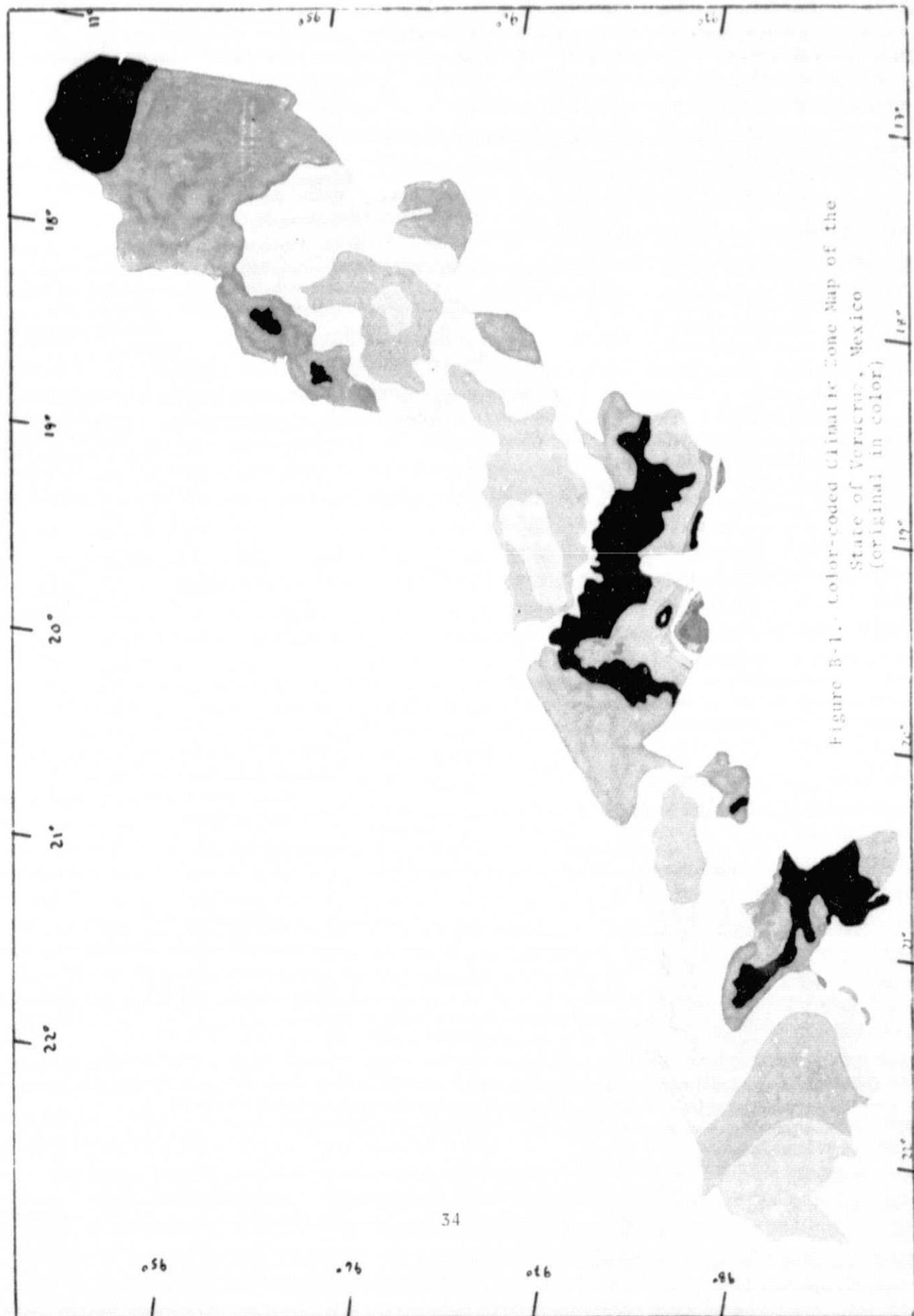


Figure B-1. Color-coded Climatic Zone Map of the  
State of Veracruz, Mexico  
(original in color)

CONTENTS OF LARSSYS II TAPE FROM  
THE IMAGE 100

CMI	Title:	Drawing	Prepared by	Date
Special <u>X</u>	Climatic Zones of Veracruz.	F.Menendez	6-15-75	
	Tape No:	Themes	C.Utterbach	8-15-75
Final	Format: 512 x 512 Number of lines to be skipped:		Conversion	R. Taub
				10-22-75

OVERALL CONTENTS

Channel 1  
 Channel 2 Themes  
 Channel 3 Themes  
 Channel 4  
 Channel 5

THEMES\* (maximum of 35; use more sheets if necessary)

<u>Channel/Theme</u>	<u>Color</u>	<u>Insert**</u>	<u>Contents</u>
2 / 2	Rosa	50	
2 / 3	Azul	40	
2 / 4	Verde claro	30	
2 / 5	Rojo	60	
2 / 6	Verde oscuro	20	
2 / 7	Café-beige	70	
3 / 2	Café	110	
3 / 3	Rosa mexicana	100	
3 / 4	Amarillo	90	
3 / 5	Turquesa	80	
3 / 6	Naranja	120	
3 / 7	Azul claro	130	
3 / 8	Negro	10	
5 / 17	Negro'	140	Border

DIAGNOSTICS

Ignore diagnostics? No

For pixels assigned to more than one theme: Insert 140

For pixels not assigned to themes: Insert 110

\* Themes are prepared in channel 5 but may be transferred to any other channel.

\*\* Write "invert" if the inverse is to be used (that is, a value inserted for all pixels not in the theme).

sheet \_\_\_\_\_ of \_\_\_\_\_

Figure B-2.-Completed Coding Form for Preparation of Climatic Zone Maps

\*\*\*\*\*  
EDIT  
TAPE NUMBER 00000  
SAMPLES 00512  
CMI/SPEC S  
3 START SCAN 1  
4 STP SCAN 512  
ZOOM  
VERTICAL 100  
HORIZONTAL 100  
SELECT CHANNEL/THEME  
2/2, CODE 050,  
2/3, CODE 040,  
2/4, CODE 030,  
2/5, CODE 060,  
2/6, CODE 020,  
2/7, CODE 070,  
3/2, CODE 110,  
3/3, CODE 100,  
3/4, CODE 090,  
3/5, CODE 080,  
3/6, CODE 120,  
3/7, CODE 130,  
3/8, CODE 010,  
5/7, CODE 140  
DIAGNOSTIC Y

Climatic  
Zone Map  
Vertical

MULTIPLE THEMES YCODE 140  
EMPTY THEMES YCODE 110

EDIT

Figure B-3.- Teletype record from DAS for conversion of Climatic Zone Map

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\* \* \* IMAGE-100 XCM

\*\*\*\*\*SHELL DENSITY MAP OF LOS TURTLES  
WILTED COTTON CLOUD AREA, KODAK FILM USED IN MOD-  
ERN EDITION © 1945

SOCIETY FOR POLITICAL ZONES OF INFLUENCE LOS TURSES POR ELLOS

WATER USE EFFICIENCY IS NOT INCLUDED IN MAP

THEME

THEME / ( #4 )

#00000000000000000000000000000000

10

THEORY : #8

卷之三

卷之三

Figure B-4.-Greymap of Los Tuxtlas portion of Climatic Zone Map of Veracruz (on three pages)

372[.....]  
 373[.....]  
 374[.....]  
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891. [ ]

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911. [ ]

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941. [ ]

951. [ ]

961. [ ]

971. [ ]

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1001. [ ]